524

SPIN-POLARIZED ELECTRON SCATTERING FROM OPTICALLY PUMPED SODIUM AT 20 eV

S.J. Buckman,* J.J. McClelland, M.H. Kelley and R.J. Celotta

Electron Physics Group, National Institute of Standards and Technology
Gaithersburg, MD 20899 USA

In order to characterize electron scattering from an atomic target at the most fundamental level, it is necessary to resolve as many scattering channels as possible. In a scattering event, these channels differ by the amount of energy transferred to the target, as in elastic and inelastic scattering, the amount and direction of the angular momentum transferred to the target, as in excitations of various M_L states in the target, and by the spin states of the electron and target.

We are studying electron scattering from sodium with spin-polarized electrons and optically pumped atoms as an approach to this fundamental level of characterization. Optical pumping of sodium, achieved with circularly polarized light from a single-frequency, stabilized dye laser tuned to the $3S_{1/2}(F = 2) \rightarrow 3P_{3/2}(F = 3)$ transition, produces either spin-polarized ground state atoms or spin-polarized, pure $M_L = \pm 1$ excited state atoms. The former are generated with the optical pumping region upstream from the scattering center, and the latter with the optical pumping region directly in the scattering center.

Thus we can study either elastic scattering from spin-polarized ground state atoms, or superelastic scattering from spin-polarized, pure angular-momentum-state $3P$ excited atoms. Superelastic scattering, in which the electron de-excites the atom and gains the 2.1 eV excitation energy of the $3P$ state, is in essence the time-inverse of the inelastic process, and provides virtually the same information as electron-photon coincidence studies of the $3S \rightarrow 3P$ excitation.

The spin-polarized electrons, produced in a GaAs source, allow the direct measurement of exchange phenomena when combined with a spin-polarized atomic target. The relevant channels for an electron scattering from a one-electron atom when exchange is important are the singlet and triplet channels. The incident electron couples with the target electron in one or both of these channels; the difference between the channels is driven by exchange.

For the present work, we have concentrated on 20 eV incident energy. Earlier work[1,2] has been done on superelastic scattering at 2 eV and elastic scattering at 54.4 eV. The present energy is in an interesting intermediate energy regime where scattering dynamics are still important and theory is somewhat challenging. For superelastic scattering, measurements have been made of $L_\perp$, the angular momentum transferred to the target perpendicular to the scattering plane, separated into singlet and triplet channels according to the analysis of Hertel *et al.*[3] Figure 1 shows the results for 17.9 eV incident energy, which is the superelastic equivalent of 20 eV incident energy for inelastic scattering. Measurements will also be presented of the ratio of triplet to singlet cross sections and $L_\perp$ for unpolarized electrons. Work is currently underway on elastic scattering at 20 eV.

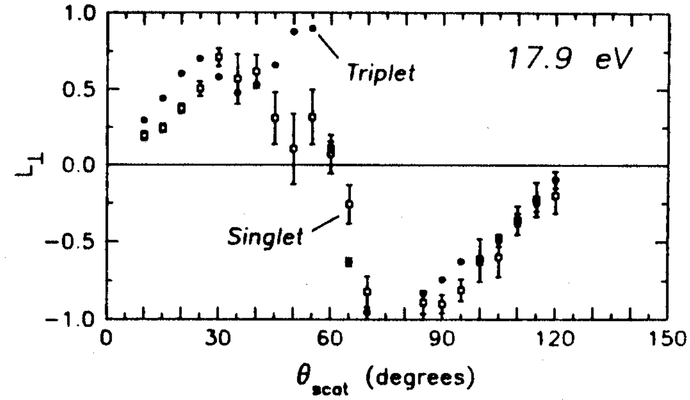

Figure 1. Singlet and triplet $L_\perp$ vs,, scattering angle θ_{scat}.

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*Permanent address: Australian National University, Canberra, Australia.

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